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APPLICATION FOR UNITED STATES LETTERS PATENT

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TITLE: Tubular Heat Exchanger With Offset Interior Dimples

Tubular Heat Exchanger With Offset Interior Dimples

Description

5 Technical Field

This invention relates generally to heat exchangers used in furnaces and the like and in particular to a tubular heat exchanger having an interior structure to enhance the turbulence of combustion products flowing through the heat exchanger tubes.

10 Background Art

Heat exchangers used in furnaces and other heating apparatus are typically comprised of plural metal tubes, each of which may be bent in a serpentine fashion to form multiple passes for the flue gas flowing in each tube. The inlet of each tube is in communication with a burner assembly in which a combustible fuel-air mixture is burned. The outlet of each tube is in communication, either directly or indirectly through a secondary heat exchanger, with a flue vent or the like, whereby flue gas is exhausted from the heating apparatus. The flue gas flowing in the heat exchanger tubes transfers heat to air passing over the outside of the tubes, whereby air supplied to an indoor space is heated.

20 It is known in the art that heat transfer efficiency may be enhanced by slowing the flow of the gaseous products of combustion in the tubes and by increasing the turbulence thereof. One approach to accomplishing both of these results is to insert one or more baffles in the tubes to break up the laminar flow of the hot gas. Another approach is to flatten the tubes at certain locations to restrict and alter the flow of the gas. Yet another approach, as described in published United States patent application 25 US 2002/0005275, is to extrude opposing pairs of dimples into the tube, so that the dimples of each pair are in alignment and form a pair of adjacent converging, diverging nozzles inside the tube.

Summary of the Invention

In accordance with the present invention, a tubular heat exchanger has at least one tube adapted to receive products of combustion in a furnace or other heating apparatus. The heat exchanger has at least one tube with an interior passageway and a wall surrounding the passageway. At least one pair of dimples projects from the wall into the passageway. The dimples are in generally facing relationship, but are offset from each other along a longitudinal axis of the tube.

In accordance with one embodiment of the invention, the tube has a generally circular cross-section and at least one of the dimples projects into the passageway beyond a centerline of the tube, so that at least one dimple projects inwardly by more than one-half of the diameter of the tube. In accordance with another embodiment of the invention, the dimples of each pair are offset from each other along the longitudinal axis of the tube by no more than one-half of the length of each dimple along the longitudinal axis. In accordance with yet another embodiment of the invention, both of the dimples of at least one pair of dimples project inwardly beyond the centerline of the tube. Each of the dimples is extruded into the passageway by deforming the tube wall and preferably defines a convex surface in the passageway.

Brief Description of Drawings

FIG. 1 is a general schematic view of a packaged air conditioning unit, comprised of a heating section, a cooling section and a condensing section;

FIG. 2 is a perspective view of a heat exchanger according to the present invention, used in the heating section of the unit of FIG. 1;

FIG. 3 is a side elevation view of one of the tubes in the heat exchanger of FIG. 2;

FIG. 4 is a sectional view, taken along the line 4-4 of FIG. 3; and

FIG. 5 is a sectional view, taken along the line 5-5 of FIG. 4.

Best Mode for Carrying Out the Invention

The best mode for carrying out the invention will now be described with reference to the accompanying drawings. Like parts are marked in the specification and drawings with the same respective reference numbers. In some instances,
5 proportions may have been exaggerated in order to depict certain features of the invention.

Referring now to FIG. 1, a packaged gas heating/electric cooling unit **10** is depicted. Unit **10** includes cooling section **12**, a heating section **14** and a condensing section **16**, all of which are housed in a single metal cabinet **18**. Cooling section **12**
10 includes an air filter **20**, an evaporator coil **22** and one or more compressors **23**. Heating section **14** includes a heat exchanger **24** and a supply air blower **26**, which is driven by an electric motor **27**. Blower **26** sits above heat exchanger **24** and when operated blows air downwardly through heat exchanger **24**. Condensing section **16** includes one or more condenser fans **28** and a condenser coil (not shown).

15 Referring also to FIG. 2, heat exchanger **24** has plural tubes **30** bent in a U-shaped configuration. An inlet end of each tube **30** communicates with one of a plurality of burners **32** and an outlet end of each tube **30** communicates with a header box **34** wherein flue products are collected after passing through tubes **30**. An induced draft blower **36** communicates with header box **34** for exhausting flue
20 products from heat exchanger **24** to the atmosphere via a conduit **37** in the conventional manner.

When unit **10** is operated in a heating mode, burners **32** burn a combustible fuel-air mixture and the combustion products are drawn through tubes **30** by induced draft blower **36**. Supply air blower **26** draws the air to be heated from a return duct
25 (not shown) into unit **10** through filter **20** to remove dirt and other debris therefrom and blows the air across heat exchanger tubes **30**, whereby heat is transferred through the tube walls from the flue products inside tubes **30** to the air flowing across the outside of heat exchanger **24**. Blower **26** blows the heated air from unit **10** into a supply duct (not shown), which communicates with an indoor space to be heated.

Evaporator coil 22, condenser fans 28 and the condenser coil are inoperative in the heating mode.

When unit 10 is operated in a cooling mode, heat exchanger 24, burners 32 and induced draft blower 36 are inoperative. A vapor compression refrigerant is circulated by one or more of the compressors 23 between evaporator coil 22 and the condenser coil in the conventional manner. The refrigerant is vaporized in evaporator coil 22, which transfers heat from air drawn through coil 22 by supply air blower 26 to the refrigerant, thereby cooling the air. The cooled air is then blown through heating section 14 into the supply duct, which conducts the heated air to the indoor space.

Referring now to FIGS. 2 and 3, each tube 30 preferably has a circular cross-section with an outer diameter of about 2 inches. Tubes 30 are preferably made of a relatively thin wall of corrosive resistant metal material, such as aluminized steel, which circumscribes a hollow interior through which the flue products from burners 32 flow in the heating mode. Each tube 30 has an inlet end 30a in communication with one of the burners 32 and an outlet end 30b in communication with the header box 34. The U-shaped configuration of tubes 30 causes the flue products in each tube 30 to make two passes through heat exchanger 24. As can be best seen in FIG. 3, each tube 30 includes first and second leg portions 30c, 30d and a return bend portion 30e. Leg portion 30c communicates with a corresponding one of burners 32 and therefore represents an "upstream" leg of tube 30, which corresponds to the first pass of the flue products through tube 30. Leg portion 30d communicates with header box 34 and therefore represents a "downstream" leg of tube 30, which corresponds to the second pass of the flue products through tube 30.

Each tube 30 has plural cooperating pairs of dimples 44 formed in the "downstream" leg 30d thereof, at predetermined intervals (e.g., 4.25 inches) along leg 30d. The "upstream" leg 30c of the tube 30, which corresponds to the first pass of the flue gas through tube 30 between inlet end 30a and return bend portion 30e, has a relatively smooth wall. As can be best seen in FIG. 5, the two dimples 44a,

44b of each cooperating pair are in generally diametrically opposed relationship, but are offset from each other along a longitudinal axis of leg **30d**. In the preferred embodiment, the amount of offset between any cooperating pair of dimples **44** does not exceed one-half of the dimple length along the longitudinal axis of leg **30d**.

5 Each dimple **44** defines a generally convex protrusion into an interior passageway **48**. Dimples **44** preferably extend inwardly beyond a central longitudinal axis of passageway **48**, so that the dimples **44** of each cooperating pair may be in at least partial contact, as best seen in FIG. 5. For example, if tube **30** has an outer diameter of 2 inches, each dimple **44** may protrude approximately 1.03 inch into
10 passageway **48**. Contact between the dimples **44** of each cooperating pair causes the flue gases to change directions and slows down their flow in passageway **48**, thereby increasing turbulence and enhancing heat transfer.

 Dimples **44** preferably are punched into the wall of downstream leg **30c** of each tube **30** on the sides thereof so that there are no constrictions in the bottoms of
15 tubes **30** to interfere with drainage of condensate therefrom. Specifically, each dimple **44** is preferably formed by deforming the tube wall inwardly by means of a spherical punching tool (not shown). The result of the punching process is a generally elliptical, concave indentation in the tube wall on the outside of the corresponding tube **30**, as can be best seen in FIG. 3, and a corresponding generally elliptical,
20 convex protrusion inside the corresponding tube **30**, as can be best seen in FIGS. 4 and 5.

 The best mode for carrying out the invention has now been described in detail. Since changes in and additions to the above-described best mode can be made without departing from the nature, spirit and scope of the invention, the invention is
25 not to be limited to the above-described best mode, but only by the appended claims and their equivalents.